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ABSTRACT

Form errors, but not reversal errors, generated when kindergarten children printed reversible letters and numbers, were associated with teachers' judgments of children's academic performance at the end of kindergarten and throughout Grade 1. Three samples totaling 166 non-repeating kindergarten children (79 male, 87 female) were drawn from eight kindergarten classes distributed among seven schools. All of the children were native English speakers. Each child was asked individually to print from memory immediately after a 2.5-second exposure to each of 41 reversible letters and numbers shown one at a time in random order on either slides or flash cards. Results support previous findings that left-right reversal errors have limited utility for identifying children with potential learning problems. It is concluded that the largely overlooked category of form error could prove useful as an aid in early screening programs. The possibility that form errors stem from the child's lack of familiarity with letters and numbers and/or a short attention span suggests that programs designed to focus attention on and provide drill with language based materials are appropriate for early interventions. (Author/RH)

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Predicting Academic Performance from Printing Errors in Kindergarten[1]

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Abstract

Kindergarten children printed from memory immediately after seeing each of the 41 reversible letters and numbers. The results showed that form errors, which involve some overall change in the actual shape of the letter itself, correlated reliably with academic performance measured at the end of kindergarten as well as throughout Grade 1 in reading, phonics, language, and math. This was not the case for the left-right reversal errors generated by these same letters and numbers. Moreover, the magnitude of the correlations suggested that these form errors hold considerable promise as a means of identifying with reasonable accuracy, children at risk for failure.

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Predicting Academic Performance from Printing Errors in Kindergarten[1]

Despite the considerable interest printing errors have generated since the turn of the century, little is known about their significance although it is widely accepted that left-right mirror-image reversals typically occur among older children experiencing academic difficulty (Clark 1970; Meier 1973). Largely because of this, reversals are often used in an attempt to identify children at-risk for academic failure (Kaufman, 1980). The present findings, however, lend support to a growing body of evidence showing that reversals, in general, have little bearing on academic achievement (Allington 1976; Calfee 1977; Cohn & Stricker 1979: Kaufman & Biren 1976). Of greater importance though, these findings point to the seriousness of a far more common although largely neglected category of error in which kindergarten children either add, delete, or misalign parts when printing, thereby producing a marked change in the overall form of the original letter itself (e.g., E → , K → , R → , S → , f →). Specifically, as part of a series of investigations (Simner 1979, 1980, 1981) concerned with children's printing, we found that these form errors, but not the reversal errors, generated when kindergarten children print the reversible letters and numbers, were associated with teachers' judgments of academic performance at the end of kindergarten as well as throughout Grade 1.

METHOD

Subjects

Three samples totaling 166 non-repeating kindergarten children (79 male, 87 female) were drawn from eight different kindergarten classes distributed among seven different schools. All of the children were native English speaking. Sample 1 consisted of 67 children tested in the early fall while Sampe 2

contained 58 children tested in the late spring. The remaining children in Sample 3 were tested in mid-winter.

Procedure

Each child, tested individually, was asked to print from memory immediately after a 2.5 sec exposure to each of the 41 reversible letters and numbers (see Figure 1) shown one at a time in random order on either slides (Sample 1 and 3) or flash cards (Sample 2). This procedure was used because it maximizes the likelihood of obtaining reversal errors while at the same time avoiding the possibility of producing form errors due to the child's lack of familiarity with the letters and their names. To avoid missing data if a child failed to recall a letter or number, it was shown again and the child was asked once more to print from memory.

Left-right mirror-image reversals were said to have taken place when all of the parts in the original letter or number were reproduced correctly and rotated 180^{o} about a vertical axis (b ↔ d). Form errors were identified according to the criterion provided above. Figure 1 contains several examples of these form errors for the each of the 41 letter and number-shapes used in this investigation. Because kindergarten children typically lack precision when printing, examples of reproductions that were judged correct also are included for comparison.

Place Figure 1 About Here

Interscorer reliability was obtained on the error scores assigned by the author and an experienced psychometrist using a randomly selected subsample of protocols from 21 children. The results showed considerable agreement in recognizing both of these error types (reversal errors: $r_{xy} = .93$, $df = 19$, $p < .01$; form errors: $r_{xy} = .97$, $df = 19$, $p < .01$).

As an index of academic performance in kindergarten, the teachers' end-of-year rank ordering of each child's readiness for Grade 1 was obtained for those children in Sample 1 and 2. These rank orderings, converted to standard z-score values, stemmed from the teachers' use of a modified version of the Criterion-Referenced Measurement Program in Reading and Mathematics (SOBAR) published by Science Research Associates and reflect the child's degree of mastery of the kindergarten core objectives established by the Board of Education. Academic achievement in Grade 1 was based on the teachers' evaluations of each child's overall in-class performance in reading, phonics, language, and mathematics as recorded on their report cards issued at the end of the first (November), second (March) and third (June) term. This information was obtained on 54 children which included all of those in Sample 3 along with 13 children from Sample 1 whose report card records were available. In addition, second term report card evaluations were also available on 53 of the Sample 2 children.

Results

Table 1 contains the product-moment correlations obtained between the teachers' evaluations of academic performance and the number of reversal as well as form errors generated in kindergarten by the 41 reversible letters and numbers. As these results show, the occurrence of form errors relate to academic performance measured at the end of kindergarten and throughout Grade 1. This was not the case, however, for the reversal errors produced by the same letters and numbers.

Place Table 1 About Here

In addition to these main findings we also have reason to believe that if form errors in printing are used for the purpose of screening children in need of some type of early assistance, such use is likely to produce relatively few false positive and false negative judgments compared to other tests specifically

designed for this purpose such as the Student Rating Scale, de Hirsch Predictive Index of Reading Failure, the Developmental Indicators for the Assessment of Learning (DIAL), and the Human Figure Drawing Test (Dunleavy, Hansen, Szasz & Baade 1981; Lichtenstein 1981; Satz & Fletcher 1979). Because the frequency of errors in printing in general declines steadily throughout kindergarten (Simner 1979) the actual form error scores produced by the children in each of the three separate samples were converted to standard z-score values. Based on a visual inspection of the data, of the 29 children from the combined sample of 166 children who either failed or were designated as being at-risk for failure by their teachers either at the end of kindergarten or Grade 1, 20 (69%) obtained a z-score of -.30 or less. In contrast, only 3 (6%) of the 54 children from this sample who were judged by their teachers to be at the top of their class, obtained z-score values within this lower range.

To ensure the reliability of these added findings using this cutoff point, a further sample consisting of 128 non-repeating kindergarten children from five different schools was tested in the early fall of the following year. The procedures were the same as those described above with the exception that the letters and numbers were administered using flash cards. In line with the previous findings, of the 26 children in this new sample who either failed or were designated as being at-risk for failure by their teachers at the end of kindergarten, 17 (65%) obtained a z-score of -.30 or less. Also, of the 47 children judged to be performing at the top of their class only 9 (19%) had z-score values of -.30 or less. Table 2 summarizes the findings from both samples by showing the mean number of children for whom true and false positive judgments as well as true and false negative judgments occurred using the children's form error scores to predict academic performance. The results in this table indicate that the overall "miss rate" (false positive + false negative/total number of children for whom predictions were made) is in the neighborhood of 19%.

Place Table 2 About Here

As these findings became known, it was considered important to ask if the form error scores remain stable over time. To answer this question, one sample of 25 children was tested initially in the late spring of pre-kindergarten, then four months later in the early fall of kindergarten. A further sample of 24 children was tested in mid-winter of kindergarten, then on a second occasion one month later. Because printing from memory proved too difficult at the pre-kindergarten level, the task was amended to allow these children to print while the pictures of the letters/numbers remained in view. The other groups were tested according to the procedures described above. The resulting product-moment correlations (r_{xy} = +.83, df = 23, $p < .01$; r_{xy} = +.87, df = 22, $p < .01$, respectively) clearly indicate that children who produce either very few or a large number of form errors when they print on one occasion behave in a very similar fashion when tested on a second occasion. Hence, considering both of these additional findings together (that is, the high test-retest reliability coupled with the low miss-rate), it would seem that form errors in printing hold considerable promise as a means of aiding in the identification of kindergarten children in need of some type of early assistance.

Parenthetically, in view of the potential usefulness of these errors in detecting at-risk children, it was also considered worth knowing if supplementary information provided by the parents could be employed to reduce the probability of false positive and false negative judgments. This was examined by administering a questionnaire to the parents of 56 children in Sample 2 prior to the end of kindergarten. Each question was selected on the basis of work by others showing that it correlated with either early academic performance, IQ, or achievement as measured on various test batteries. The final list included questions on perinatal medical history, diet, preschool academic experiences, home stimulation,

education and occupation of the parents, birth date, birth order, and home stability (number of moves, marital status, daily routine, etc.).

As expected, the results produced a number of significant correlations with end-of-year performance in kindergarten. However, none exceeded the correlation generated by the form error scores alone. Moreover, using a stepwise regression procedure only two of the variables (number of books at home and child's age at the time of testing) when coupled with the form error scores, produced a reliable ($p < .01$) increase in the resulting multiple correlation. Unfortunately, though, the predicted class standings generated by the regression formula containing the beta weights associated with each of these three variables (form errors, books at home, age at testing,) when obtained on this sample coupled with a further sample of 30 children for whom this information was also available, showed no reliable change in the number of false positive and false negative judgments. Therefore, we have no reason to assume that knowledge of background variables of the type normally found on many early screening devices can improve the level of information already conveyed by considering these form error scores alone.

Discussion

The findings from this investigation underscore evidence reported by a number of others showing that left-right reversal errors have limited utility when employed for the purpose of identifying children with potential learning problems (Allington 1976; Calfee 1977; Cohn & Stricker 1979; Kaufman & Biren 1976). To be sure, there are some studies showing a relationship between reversal errors and academic ability. With few exceptions though in these instances the relationship is either marginal (Black 1973; Lewis & Lewis 1965) or the test itself was composed primarily of items presented in a matching-to-sample format and the reversals measured were reversals of sequence (was → saw) not reversals of individual letters (e.g., Kaufman & Kaufman 1980).

While this point regarding sequence reversal errors and the use of a matching-to-sample format is often overlooked by those who argue in favor of employing reversals to predict academic performance, it could be of considerable importance. Lieberman, et. al. (1971), for example, found that sequence reversal errors related to reading performance while single letter reversal errors did not. Furthermore, these two error types were uncorrelated suggesting that they might even stem from different underlying sources. Also, Sidman & Kirk (1974) have shown that reversal errors are more common when children identify reversible letters using a matching-to-sample procedure then when they print. This of course could mean that when relationships are obtained between reversal errors and later academic performance based on tasks involving matching-to-sample techniques, such relationships might reflect the child's problem with the task itself more so than his or her tendency to reverse per se. For example, performance on the Matching Familiar Figures Test, which employs a matching-to-sample technique and places no importance on reversal errors, also relates to academic achievement (Messer 1970). In other words, if tests designed to measure the frequency of left-right reversal errors were scored for errors other than orientation errors, these other errors might yield correlations similar in magnitude to those obtained based on the reversal error scores alone. In line with this point, Leiberman et. al. also reported that errors involving consonant as well as vowel substitutions correlated more strongly with performance on the Oral Gray Reading test than did sequence reversal errors. Cohn & Stricker (1979) obtained very similar results using a letter naming task. While this is not intended to suggest that left-right reversal errors have no clinical significance (see Royer & Holland 1975 for a more complete discussion of this issue), these possibilities do indicate the need for exercising considerable caution when forming conclusions regarding a child's learning potential based on the child's tendency to produce left-right reversal errors.

On the other hand, the evidence dealing with form errors in printing clearly indicates that this largely overlooked category of error could prove quite useful as an aid in any early screening program. In fact, the range of correlations shown in Table 1 compare very favorably with those obtained using such popular "readiness" tests as the Wechsler Preschool and Primary Scale of Intelligence, the de Hirsch Predictive Index of Reading Failure, the Otis-Lennon Mental Ability test, the Bender Visual Motor Gestalt test, the Goodenough-Harris Draw-A-Man test, the Gates Reading Readiness test, and the Lorge-Thorndike Intelligence test (Feshbach, Adelman, & Fuller 1974; Harris 1963; Mendels 1973; Silberberg, Silberberg, & Iversen 1972). Moreover, in view of the questions that have been raised concerning the diagnostic utility of many of these tests (e.g., Calfee 1977; Salvia & Ysseldyke 1978; Silberberg, Silberberg, & Iversen 1972) coupled with the amount of time they require to administer and score, if screening for potential learning problems per se is the major purpose of early testing, a useful alternative might be to employ the procedures in this investigation. Using flash cards, test time and scoring time average 10-15 minutes per child. The cutoff point z-score values reported above translate into 18-19 errors for children tested in October-November and 7-8 errors for children tested in May-June of kindergarten[2].

Finally, with the ultimate aim of establishing an early intervention program designed to assist the at-risk children identified by this error type, it is worth asking why form errors in printing relate to later academic performance. Two possibilities come to mind. First, despite the fact that all of the children printed from pictures, these errors still might stem from the child's overall lack of familiarity with letters and numbers. Retesting 28 of the Sample 2 children showed that the total number of letters/numbers named correctly as they appeared on the screen correlated -.52 ($df = 26$, $p < .01$) with the number of form errors produced. Moreover, it is well known that the ability to name the letters

and numbers in kindergarten correlates quite highly with performance in Grade 1 (Calfee 1977; Silberberg, Silberberg, & Iversen 1972). Therefore, it could very well be that form errors in printing relate to later school achievement in reading, phonics, language, and math, at least in part, because these errors reflect inadequate experience with certain basic materials upon which later success in these areas depends.

A second way of explaining this relationship stems from recent findings that link the occurrence of form errors to momentary lapses in the child's attention to detail (Simner 1979). If these lapses also occur throughout the school day, perhaps children who produce many form errors do less well than their peers because they have more trouble attending to the material taught in class. In other words, what might appear on the surface to be a learning deficit in these children, could, in reality, stem from the child's difficulty in maintaining his/her attention when confronted with the normal distractions found in a typical kindergarten and 1st grade classroom.

In line with this possibility, we have some further evidence showing a relationship between the number of form errors obtained in kindergarten and the kindergarten child's attention span in class as judged by their teachers. Specifically, each kindergarten teacher was asked to rate the children in her class using a 10 point scale with 10 indicating good general attention span in class and 1 reflecting poor in-class attention. The resulting product-moment correlations showed a fairly strong relationship between these two variables (Sample 1: r_{xy} = -.69, df = 65, $p < .01$; Sample 2: r_{xy} = -.53, df = 54, $p < .01$). Moreover, those children said to have a poor attention span in kindergarten, were also less likely to do well academically in both kindergarten and in Grade 1. That is, these kindergarten teacher ratings of the child's in-class attention span correlated highly with the children's subsequent academic performance measured at the end of kindergarten (Sample 1: r_{xy} = .65, df = 65, $p < .01$; Sample 2: r_{xy} = .65, df = 54, $p <$

.01) as well as at the end of Grade 1 in reading (r_{xy} = .58, df = 51, $p < .01$), phonics (r_{xy} = .63, df = 51, $p < .01$), language (r_{xy} = .59, df = 51, $p < .01$) and math (r_{xy} = .57, df = 51, $p < .01$). This, of course, agrees with work by others (Samuels & Turnure 1974) showing a relationship between the child's degree of attentiveness in class in Grade 1 and his/her subsequent reading performance also measured in Grade 1. Hence, if form errors in printing are used as an aid in early screening, the possibility that these errors might stem from the child's lack of familiarity with letters and numbers coupled with the child's short attention span, suggests that perhaps the at-risk children identified by this error type might profit from being placed in a highly structured program designed both to focus and maintain the child's attention while at the same time providing the child with increased drill in language based materials. The Direct Instructional Model described by Becker and Engleman (1978) is one example of such a program that has met with some success (Miller & Dyer 1975).

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Table 1. Product-moment correlations obtained between the number of reversal as well as form errors in printing generated in kindergarten and teachers' end-of-year-evaluations of academic performance in kindergarten and throughout Grade 1.

Kindergarten Performance

Sample	Error Type	Correlation
1 (N=67)	Reversal	r_{xy} = -.18
	Form	r_{xy} = -.67**
2 (N=58)	Reversal	r_{xy} = -.15
	Form	r_{xy} = -.53**

Performance throughout Grade 1

Term	Error Type	Subject Area			
		Reading	Phonics	Language	Math
1st (N=54)	Reversal	-.11	-.15	.00	.00
	Form	-.54**	-.57**	-.40**	-.07
2nd (N=54)	Reversal	-.20	-.19	-.07	-.05
	Form	-.53**	-.59**	-.60**	-.41**
(Sample 2) (N=53)	Reversal	-.01	-.14	-.19	.00
	Form	-.51**	-.27*	-.37**	-.65**
3rd (N=53)	Reversal	-.13	-.20	-.09	-.22
	Form	-.48**	-.48**	-.36**	-.40**

** $p < .01$

* $p < .05$

Table 2. Prediction of teachers' end-of-year performance evaluations using form errors in printing. The cells contain both the mean number and percentage (in brackets) of kindergarten children from two independent samples for whom either true or false positive as well as true or false negative judgements occurred.

	Teachers' End-of-Year Performance Evaluations	
Form Errors	at-risk for failure	top of class
poor prognosis (z-score of -.30 or less)	(true positive) 18.5 (67%)	(false positive) 6 (12.5%)
good prognosis (z-score greater than -.30)	(false negative) 9 (33%)	(true negative) 44.5 (87.5%)

Letter	REPRODUCTIONS JUDGED CORRECT	FORM ERRORS	Letter Number	REPRODUCTIONS JUDGED CORRECT	FORM ERRORS
B	B B B B B	B B B B B	9	9 9 9	9 9 9 9 9 9
C	C	6 C S U Q	h	h h h	h n b n n P r
D	D D	O C P □	j	j j	j J J J J
E	E E	E S F E	k	K K K K	K K K K K K
F	F F F	E F	m	m m m	m m r m n
G	G G G	C G G G 6 b	n	n n n	n r n n P h
J	J J	J U J	P	P P	P P P R
K	K K K	K K N F K K	q	q q	q q q q R q
L	L L	L ⊥	r	r r r r	r r r r P
N	N N	M N r n	s	S S	S 9 9 3
P	P P	q O O P P P	u	u u u u u	U U 4 r 4 4
Q	Q	Q O O Ø O	y	y y y	Y Y h h 4
R	R R R R	K R R R 9 R R	z	7	3 P J L L 2
S	S S	S 2 S	2	2 2 2 7 2	2 S c 2 2 7
Z	Z 2 z z z	2 3 7 2 3	3	3 3	3 3 3 2 3
a	a a a	q O d n A d	4	4 4	H Y 4 4
b	b b 6	F D P D 6 O 6	5	5 5	5 S Z 5 S
c	c	6 a C	6	6 6 6 6 6	9) P S
d	d	q I 8 6 d	7	7 7	7 P 2 Y)
e	e e	e E e P e P	9	9 9 9	>
f	f f f	f F C R			

Figure 1. Examples of form errors in printing produced by kindergarten children for each of the 41 reversible letters and numbers. Reproductions judged correct are included for comparison.

Footnotes

[1]A preliminary version of this paper was presented at the Biennial Meeting of the Society for Research in Child Development, Boston, 1981.

[2]For detailed instructions on the administration and scoring of this printing task contact the author.